CONSTRUCTION PROJECT MANAGEMENT

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CONSTRUCTION PROJECT MANAGEMENT
Program Digest

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Overview

U. S. urban rail construction projects have become extremely expensive; design and construction costs of $60 to $100 million per mile are now not unusual. UMTA research reveals a consensus among experts that inefficient management of these projects may be a major contributor to these high costs. Experience in other countries, where the environment for management often appears more conducive to efficiency and where much lower costs are experienced, bears this out.

Some of the problems managers of rail construction in cities face are: the necessity to route lines around existing structures; the resistance to the project produced by its noise, dirt, traffic problems, and harm to buildings and roads; the complexity of federal and state grant processes; the uncertainty of complex labor relationships; the difficulties of acquiring land and rights-of-way; and, perhaps most important, the dynamic planning, funding, and scheduling of many contractors working together in difficult urban conditions. Since urban rail construction projects last for years, the penalties for allowing these problems to stretch the schedule and keep contractors on-site, but not producing, can be enormous.

There are now some 100 additional miles of urban rail transit systems planned in our cities. Should each rail system mile cost $100 million, the total expense to the United States will be a nearly unaffordable $10 billion. However, if efficient management systems and constructive relationships with contractors and labor can substantially reduce these costs, the alternative of mass transit to the petroleum-dependent highway and automobile can become very attractive. This is why the Urban Mass Transportation Administration (UMTA) has focused technology, development, and deployment (TD&D) on successful urban rail construction project management.

Management of urban rail transit construction projects is always difficult because the work must be done in, around, and under the structures and streets of a busy city.

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Program Objectives

UMTA TD&D seeks construction management techniques which result in the lowest cost for successful urban rail transit projects.

The program generally draws upon proven success. Studies have sought information on the most important aspects of the international urban rail transit construction management experience, have secured wide professional commentary on that experience and then, using recognized experts, have documented specific management techniques for use in ongoing and future urban transit construction projects.

Organization

Technology development and deployment (TD&D) projects in rapid transit construction are carried out by the Office of Rail and Construction Technology in UMTA's Office of Technology Development and Deployment, Washington, D.C. UMTA awards both TD&D grants and contracts under the program. Under a working agreement, the U.S. Department of Transportation's Transportation Systems Center (TSC) in Cambridge, Massachusetts, provides a wide range of technical support to the program and awards TD&D contracts under UMTA sponsorship. An organiza-

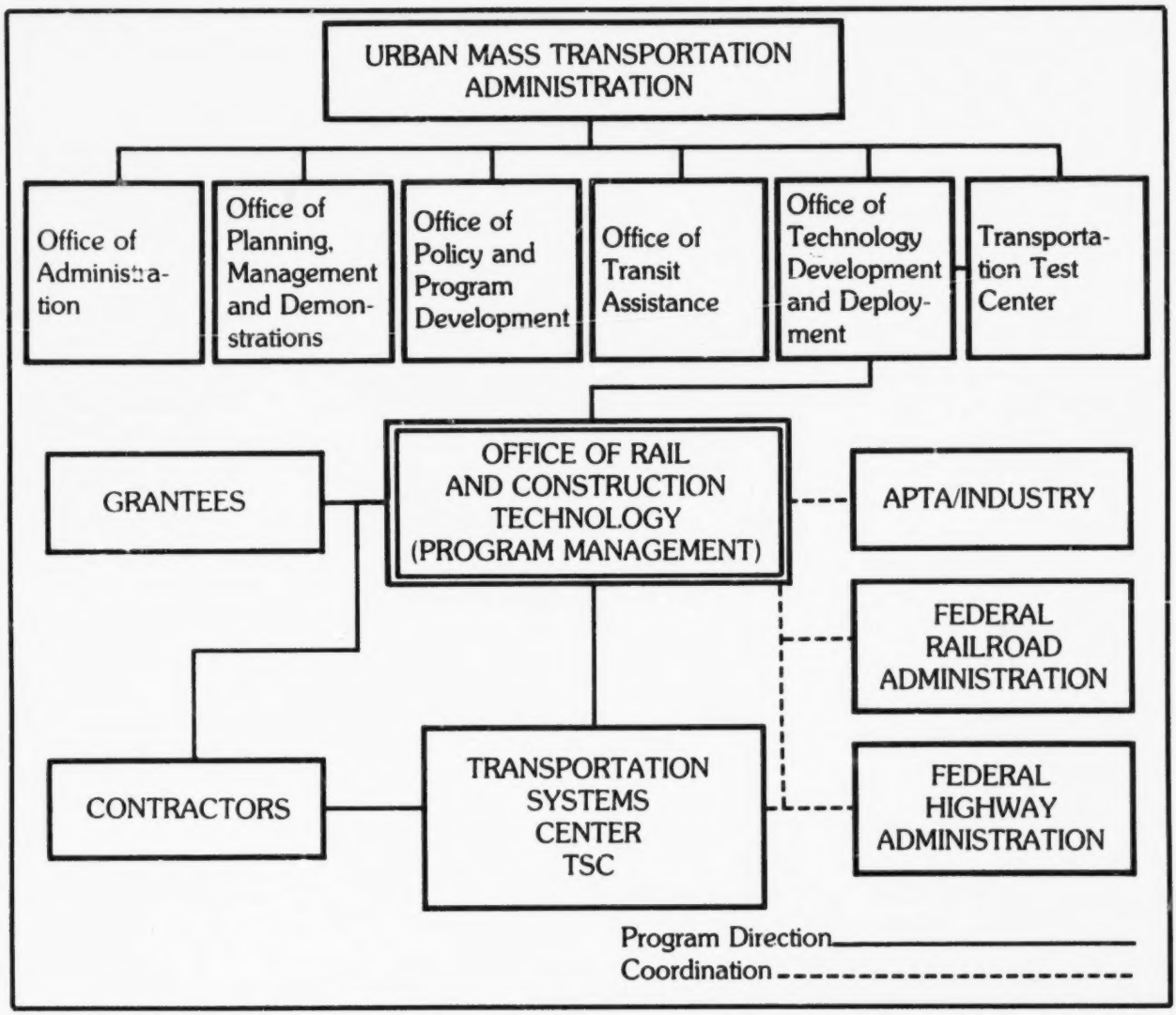


Figure 1
Organization Chart of Urban Rail Construction Technology Program

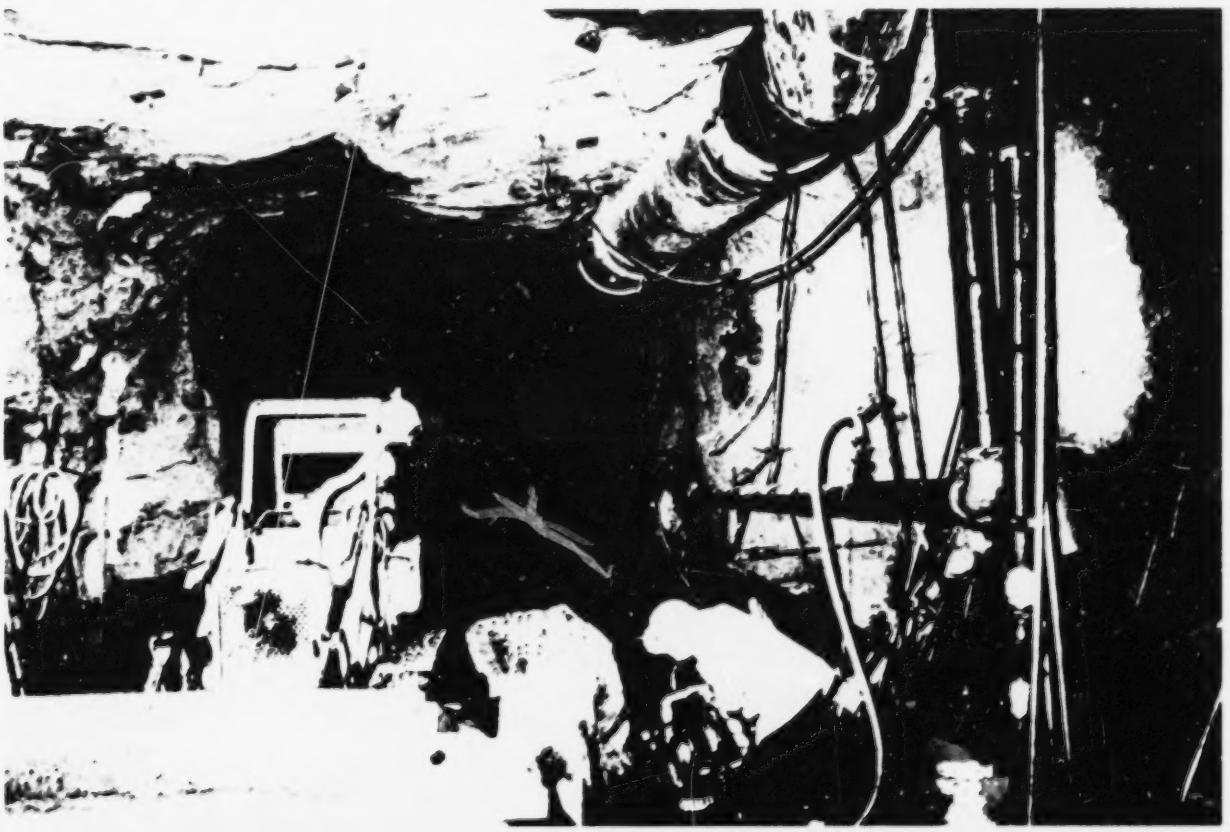
tion chart reflecting the UMTA Urban Rail and Construction Technology Program is shown in Figure 1.

In 1971, the Federal Council for Science and Technology established an Interagency Committee on Excavation Technology (ICET) to facilitate the coordination of all federal agencies with TD&D programs in excavation technology through sharing of results and avoidance of duplication. UMTA and the Federal Highway Administration (FHWA) were members of ICET together with the Bureau of Mines, Bureau of Reclamation, Geological Survey, Army Corps of Engineers, Environmental Protection Agency, Defense Nuclear Agency, Air Force, and Department of Energy.

In 1973, the DOT Transportation Tunneling Program was established to coordinate TD&D programs in tunneling being carried out by the Office of the Secretary (OST), UMTA, FHWA, and the Federal Railroad Administration (FRA). The program was directed toward determining urban transit, highway, and railroad tunneling needs and the establishment of R&D priorities to meet those needs. As the present construction technology program evolved, the OST and FRA programs were transferred to UMTA, and in 1979, UMTA and FHWA established a Tunneling and Construction Coordinating Council for their respective tunneling programs, as well as other construction technologies.

In addition, several other groups involved in construction technology are invited to participate in research and development and the exchange of information, including the National Academy of Sciences' U.S. National Committees on Tunneling Technology and Rock Mechanics, the American Public Transit Association, professional associations, and private contractors, engineers, planners, and designers.

Urban rail construction projects are difficult for everyone, from the owner's top management to workers on the site. For morale and productivity to be high, it is necessary that clear incentives for good, cost-efficient work be emphasized in contracts and management.



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Program Summary

System owners are generally not in the urban rail construction business, but rather start a single large project with little specific formal management experience. Federal support of TD&D in urban rail management is advisable so that the lessons learned in mature projects, often at excessive cost, are crystallized and transferred to other cities in the country.

The results of UMTA's projects are available in a series of documents described in this report and listed in the bibliography. Most are available through the National Technical Information Service (NTIS) of the U.S. Department of Commerce. To encourage and accelerate the adoption of proven management techniques, UMTA sponsors direct liaison among urban rail design and construction project managers and promotes conferences for direct interaction among professionals in the rail construction community.

This document is a digest of the UMTA program in management of urban rail projects. It is intended to be read by a wide audience, including transit owners, consultants and contractors and their associates in engineering, law, regulation, and insurance. The studies have been grouped into two primary subject areas, described briefly below and detailed in the subsequent sections.

1. Planning

UMTA co-funded development of a model management process (4)* for large urban transit construction projects. A hypothetical construction project was described, from its earliest phases through completion. Then, elements of project management were discussed, including project phasing, organizational alternatives, and management problems. Six broad recommendations for sound management, based on the consensus opinion of the experts interviewed, were identified and these in turn were broken down into thirty-four specific recommendations. Finally, an expert consensus of the issues critical to successful management of such projects was presented, along with recommendations for the most fruitful options for handling these issues.

This case study model and analysis can be used by transit owners as a baseline for their own successful management practices.

To capture the direct commentary and thought of a wide variety of professionals, UMTA later sponsored and organized a conference on construction of urban rail transit systems (8). This conference featured presentations by recognized experts and elicited "give and take" through panels of their colleagues, with speakers, and with the audience. The focus was on management problems which produce excessive project cost. Topics were covered from the owners', designers', and contractors' points of view. Specific technical topics covered were insurance and bonding, value engineering, construction management, management R&D, and technology R&D.

Finally, UMTA funded development of guidelines for the critical parts of the management plan necessary for adequate control of major urban transit projects. These were reported in two documents, one an overview which described the elements of a plan (6), the other containing specifics of examples from successful project planning efforts (7).

2. Agreements and Relationships With Contractors

One project (3) utilized a group of experts to compare contracting practices in the United States to those in a number of European countries. The effects of the contracting relationship on contractor performance and incentives toward project economies were analyzed. From this analysis, seventeen specific recommendations for change to U.S. contracting practices were derived. Additionally, descriptions of a variety of useful contract formats were presented.

To address the question of constructively allocating risk, UMTA co-sponsored development of a formal methodology (2) for quantifying the costs to owners and contractors for assuming

* Numbers in parentheses refer to studies listed in the bibliography.

various project risks. This procedure was based on formal decision analysis methodologies and was worked out in substantial detail for application to urban rail transit construction projects. Both the theoretical underpinnings and practical working of the process were presented. Additionally, use of the analytical process to analyze the insurance decisions on a hypothetical project was documented. These results were compared with the insurance package actually used on a similar project.

The process was used to analyze the insurance alternatives offered to an actual rail transit construction project. The results indicated a major savings through a specifically tailored "wrap-up" insurance program with high deductible limits.

UMTA now has a study underway to extend this technique to include the role of the designer in making fundamental risk decisions. The result anticipated is a versatile, powerful management tool helpful in making the cost-sensitive decisions in urban rail construction management.

UMTA funded a thorough analysis of the insurance history of each of the nation's major urban rail transit construction projects (5). The analysis distilled the experience of construction and insurance experts and of the insurance specialists, transit system owners and contractors involved in the projects. The result was a detailed prescription for developing a project insurance package and recommendations regarding the most important actions and the options available.

Once a project has been planned, management must be vigorous and informed. To have the will to succeed, participants must have vested interest in success.

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1. Planning

Because urban rail transit construction is complex and lengthy, planning of its management is of paramount importance. Major urban rail construction projects accelerate enormously as time goes by, both in terms of the pace of events and expenditure and in terms of the number of participants and decisions which must be controlled.

The experts whose counsel UMTA has sought agree that careful, early planning of management structure and process is essential to the success of urban rail transit projects. Similarly, the management studies conclude that early establishment of clear goals and explicit delegation of authorities and responsibilities to participants are essential to project economy. There was also agreement that mechanisms for quick decision and resolution of difficulties and alternatives must be provided from the outset.

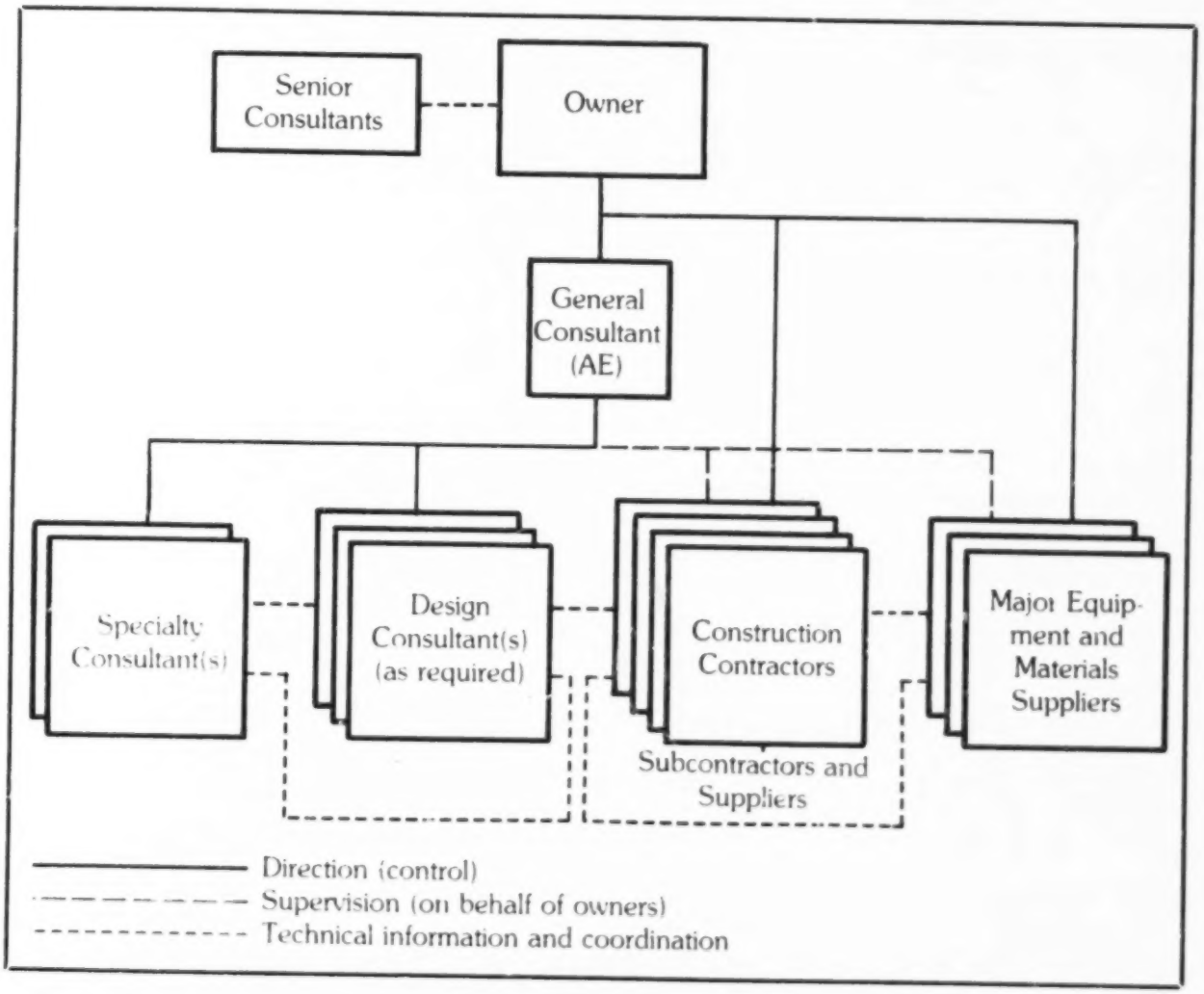

Figure 2
Project Organization. General Consultant Manages Design and Construction for Owner. This Diagram Shows Design Consultants as Subcontractors to the General Consultant. Technical Supervision of Design Consultants May Also Be Provided by the General Consultant on Behalf of the Owner, to Whom Design Consultants Are Under Contract.

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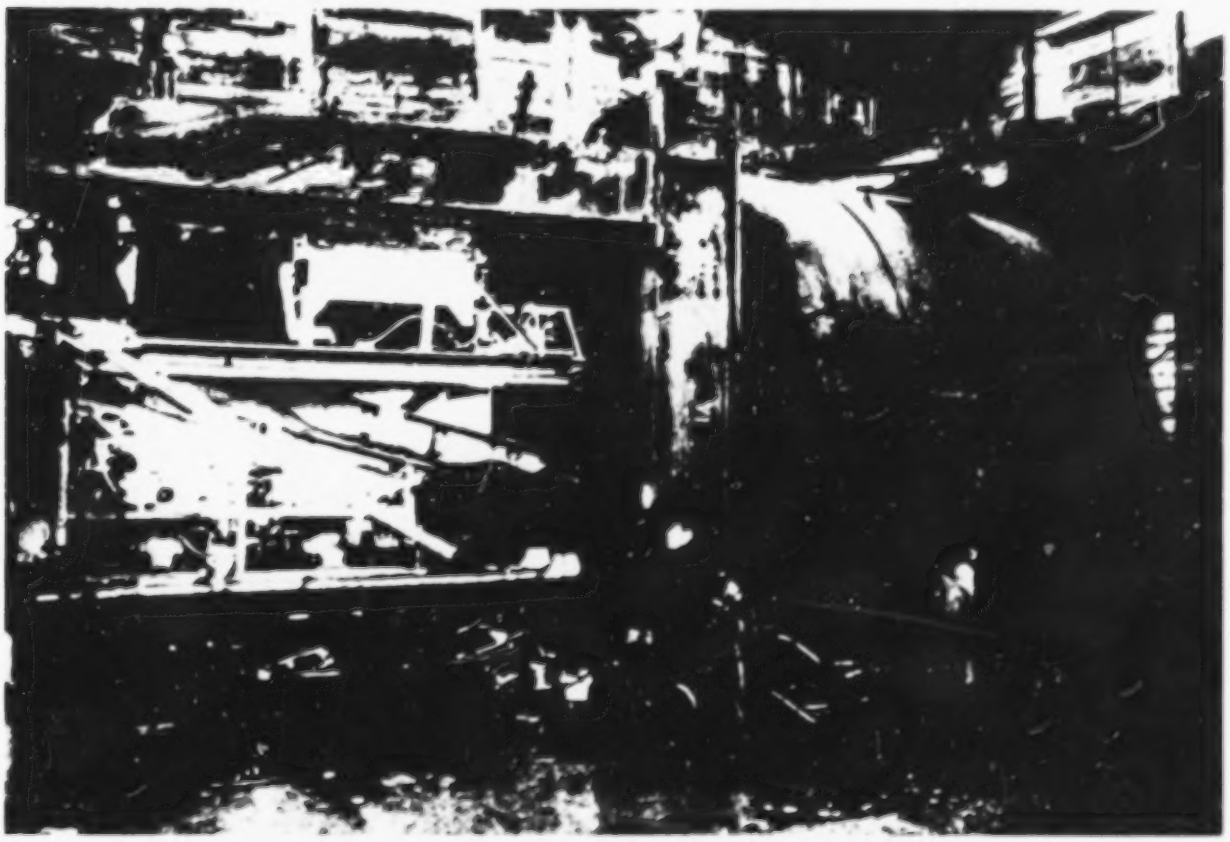
Management Structure and Process

In the analysis of management of underground construction which UMTA funded in 1978 [4], a case study emphasized the importance of stimulating a "can do, will do" attitude in project personnel from on site workers to managers—and the support quick, clean decisions give to this positive morale factor. Additionally, special emphasis was given to the importance of continuity of knowledge and management throughout the life of the project. In this regard, the study emphasized the crucial importance of an appropriate management structure.

For the case study, the structure shown in Figure 2 was judged to be most appropriate because it reduced the need for owner in-house capability and yet provided retention of professional knowledge throughout the project. This structure provides a general engineering consultant to advise and assist in developing finance and insurance programs and in working out contracts and labor agreements, to perform most of the preliminary engineering, to perform or contract final engineering design and, at the option of the owner, to provide construction management.

Emphasis was placed on evaluation of the consultant's previous performance, in-house capability in required disciplines, and particularly, construction management experience. Additionally, the importance of clear definition of the extent and design approach of the project in the RFP was stressed. The study recommended that the consultant comment on the project design and offer alterations to it in his proposal, both to benefit the project and as an important insight

As the complexities of the job reveal themselves during construction, thorough planning and decisive management permit the schedule to be met.



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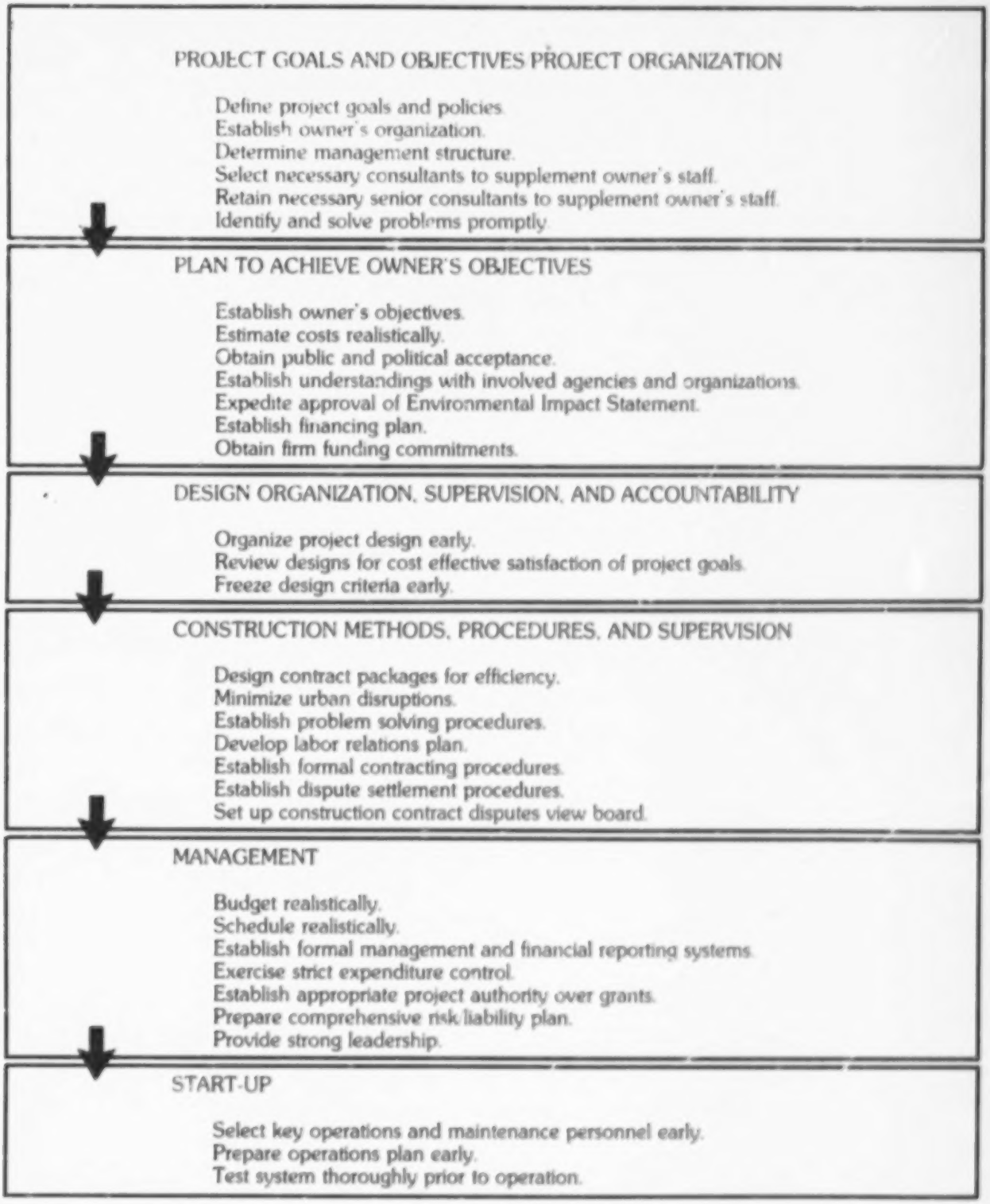
PROJECT GOALS AND OBJECTIVES PROJECT ORGANIZATION
Define project goals and policies.
Establish owner's organization.
Determine management structure.
Select necessary consultants to supplement owner's staff.
Retain necessary senior consultants to supplement owner's staff.
Identify and solve problems promptly.
PLAN TO ACHIEVE OWNER'S OBJECTIVES
Establish owner's objectives.
Estimate costs realistically.
Obtain public and political acceptance.
Establish understandings with involved agencies and organizations.
Expedite approval of Environmental Impact Statement.
Establish financing plan.
Obtain firm funding commitments.
DESIGN ORGANIZATION, SUPERVISION, AND ACCOUNTABILITY
Organize project design early.
Review designs for cost effective satisfaction of project goals.
Freeze design criteria early.
CONSTRUCTION METHODS, PROCEDURES, AND SUPERVISION
Design contract packages for efficiency.
Minimize urban disruptions.
Establish problem solving procedures.
Develop labor relations plan.
Establish formal contracting procedures.
Establish dispute settlement procedures.
Set up construction contract disputes view board.
MANAGEMENT
Budget realistically.
Schedule realistically.
Establish formal management and financial reporting systems.
Exercise strict expenditure control.
Establish appropriate project authority over grants.
Prepare comprehensive risk liability plan.
Provide strong leadership.
START-UP
Select key operations and maintenance personnel early.
Prepare operations plan early.
Test system thoroughly prior to operation.

Figure 3
Emphasis Areas for Project Management

into his capabilities. These factors—rigorous evaluation of the design agent's competence and early definition of the goals of the project—were highlighted in other UMTA studies.

The study developed a prioritized listing of elements judged to be critical to project economic success and a chronological discussion of typical problems observed during major construction projects.

Expert opinion regards delay as the major problem in construction management. Delay results in inflation cost, requires that participants inefficiently "work around" postponed design or construction, and in many cases prohibits completion of the original project design. It is during organizational phases that the owner has the greatest opportunity to avoid delay, by constructing a firm organizational foundation for his project.

The study produced thirty-four specific recommendations in six major categories. These are listed in Figure 3. The themes noted earlier of clear decision, continuity of professional participation and avoidance of delay run through these recommendations.

UMTA sponsored a conference convening experts from throughout the urban rail transit design construction community (8). The participants agreed on the necessity for clear management decision and clean lines of authority and responsibility for execution. The participants felt that in public projects, which depended on federal grants and which must meet a multiplicity of federal, state, and local legislative and funding requirements, a special effort must be made to inhibit confusion of the decision process through the many necessary levels of review.

A major topic at the conference was the application of value engineering to urban rail transit projects. The value engineering concept, in which the design is reviewed after its preparation for opportunities of cost saving, has been applied successfully in major projects, many of the participants felt.

A good portion of the conference focused on the need for good definition of labor agreements before construction begins and the necessity for projects to operate in as harmonious a labor environment as possible. This theme—the importance of avoiding adversarial relationships—was picked up as essential in other studies discussed in this digest. Similarly, the conference emphasized the expense of delay.

Management Plan

UMTA funded development of guidelines for project management plans (6) and (7). The committee which carried out this work reached basic conclusions very similar to those of the study discussed in the previous section: "Delays . . . result in the greatest losses. . . . A lack of understanding of authority and responsibility . . . generally exists. . . . These differences, together with an adversarial relationship . . . increase the likelihood of costs and disputes." The committee recommended that: "Decision making . . . should be identified and defined and the requisite responsibility and authority should be assigned. . . ."

The central recommendation of the study was that a fully developed, written project management plan be prepared early in the project and then maintained throughout its life. Development of a useful plan depends on extensive conceptual planning, including consideration of transit system needs, demography, economics, social and environmental impact, financing and public and political support. Writing the plan documents the results of these studies and thereby gives direction to the project, highlights areas which have not been resolved and provides the basis for assigning decision relationships.

The first volume documenting the study (6) identified sixteen elements necessary to an urban construction plan (Figure 4). Although all are important, a few were deemed to be critical to the economic success of a project.

Parameters and constraints is the description given the information that comes from conceptual planning of a project—crucial to the project's success. This includes two major areas. The first is the *project description*, which includes *physical description and function* of the planned system; *the budget*, broken down by major physical components and functions; and *the schedule*, broken down to the level of completion of major system

- Parameters and Constraints
- Organization and Staffing
- Management Control Systems
- Human Resources and Labor Relations Policy
- Risk Management
- Dispute Resolution
- Procurement
- Design Program
- Real Estate Acquisition and Disposal Program
- Construction Program
- Communications Program
- Legal Requirements
- Safety Program
- Operation and Maintenance Interface
- Communication Interface Management
- Maintenance of the Plan

Figure 4
Recommended Elements of Project Management Plan

components and including all major milestone events. The second is *legal authority and requirements*, which includes a description of *statutory authority* for elements such as real estate acquisition, local financing and procurement; *regulations*, including environmental, health and safety, civil rights and codes and ordinances; and *existing governmental structure*, such as building, planning, fire, health, public works and transportation departments which have power over decision-making approval.

Organization and staffing—especially regarding the work in-house staff will do versus that which contractors will do and delegation of authorities and responsibilities between the owner and his contractors—was judged to be of prime importance. The plan should contain: 1) a complete organization, including time orientation to describe how staffing will change as the project progresses; 2) identification of key personnel and their principal duties, reporting relationships and authorities; 3) interface points; 4) intra-company organizations showing personnel assigned and interface points; and 5) a staff mobilization plan.

A management control system, based on a work breakdown description of the project, is essential. The use of critical path method (CPM) networks should be considered.

Human resource and labor relations policy, especially in the area of labor agreements, was deemed to be of substantial importance, as were *plans for real estate acquisition and disposal* and *communications* with project participants, outside agencies and the public.

The second volume (7) documented the plan by examples drawn from actual practice. In some cases, the material presented represents a consensus of the committee, drawn from their experience and from the interviewing process used during the study. In others, the primary intent was to describe those elements essential to a successful management plan, rather than to illustrate a particular approach.

For instance, cost control was illustrated through reference to aspects of project cost control used by the Metropolitan Atlanta Rapid Transit Authority (MARTA). MARTA emphasizes the connection between cost control management and a clear description of the system through a work breakdown structure (WBS). The WBS permitted breakdown of the project into what MARTA termed construction contract units, for which clear authority and responsibility could be assigned. The MARTA experience indicates that controlling escalation of cost estimates during the design phase is important in maintaining overall project cost control. MARTA utilized a system in which changes in cost estimates were recognized as performance elements of the design agent's job and his fee was tied to maintenance of overall cost limitations. Echoing the conclusions of other UMTA studies, MARTA found it necessary to assure that early planning was thorough and complete and received complete review, and to

maintain very tight management control over change proposals.

The report recommended frank analysis of the history of labor and union performance in the project area. Project agreements with internationally-recognized unions were recommended in areas where a history of frequent strikes, weak local unions or work stoppages was evident. In situations where local labor agreements were uniform and backed by strong and stable labor management, these agreements were recommended for adoption as the basis for project agreements. The study recommended against a combination of open and union shops within one project.

Risk management and associated insurance and bonding was the topic of extended treatment. An overview of the elements of risk identification and risk control was given and an analysis of appropriate types of insurance was indicated.

An overview of basic contract types and the criteria for their selection in various project settings was given. In general, contracts with shared risk and incentives for contractor economic and quality performance were recommended where the project is well defined.

The study analyzed the authorities and responsibilities and the performance which should be expected from a construction manager, with special emphasis on the interfaces between his activities and those of the owner.

Experience the world over shows communication with the public, especially those directly affected by construction, pays great dividends in understanding and support of urban rail projects.

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2. Agreements and Relationships With Contractors

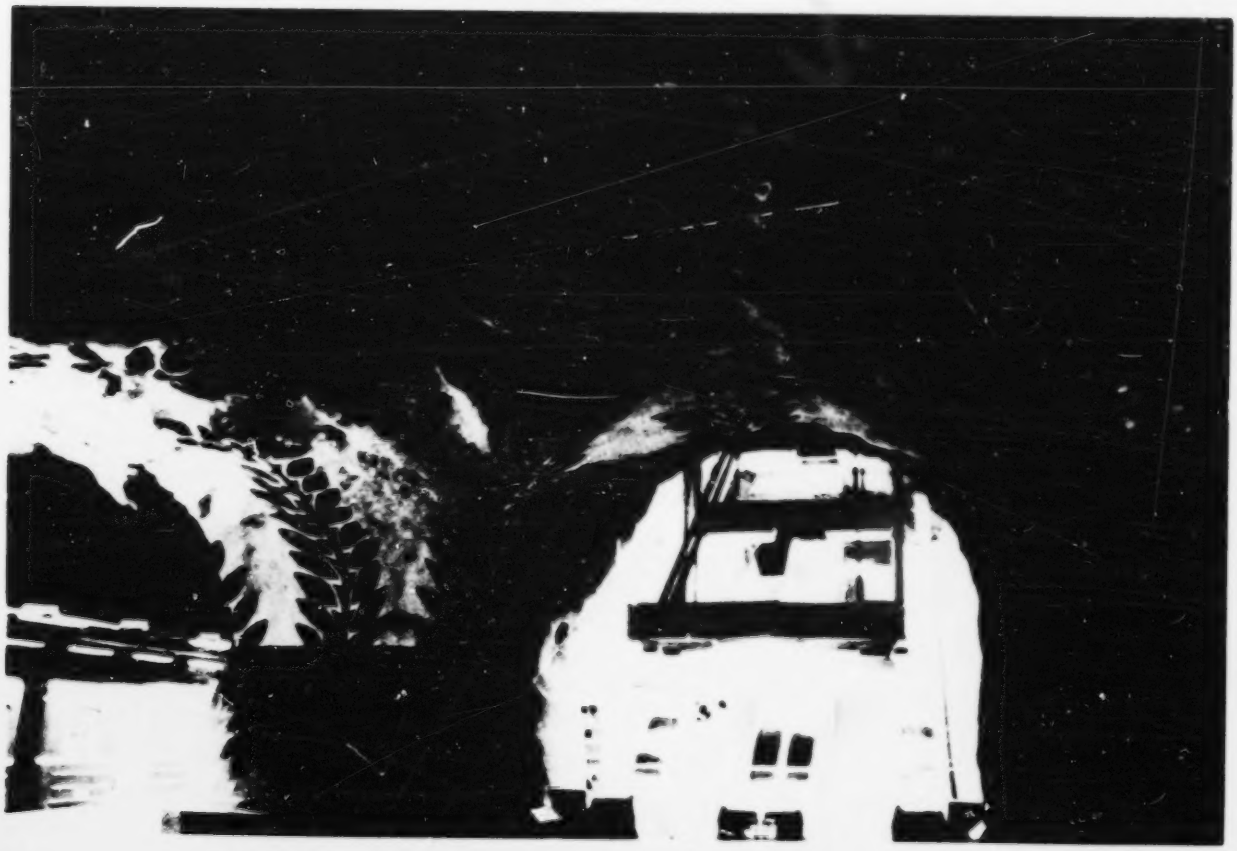
A fundamental problem for urban transit development is divergence of the interests of the transit owner and his contractors. Typical U.S. contracting practice can officially establish deeply adversarial relationships which direct creative energies away from project success.

UMTA's research has identified a number of agreements which, if made before the project starts, can provide powerful incentives for the participants to increase the economy of their effort. One major opportunity occurs in the method of selecting contractors—designers, construction managers, insurance administrators, and construction contractors—and in writing their contracts so that efficient performance is rewarded and lack of economy carries a penalty. A second is careful risk analysis and risk management at the beginning of the project. Another is structuring insurance programs to capitalize on the risk capabilities of the participants and secure the least overall project insurance cost.

Contracts

The 1974 study on contracting for underground construction (3) was undertaken to ". . . develop improved contracting methods . . .

A major part of UMTA's research on urban construction contracting systems was based on a review of European practice. Based on the information gathered in this review, UMTA's research team determined that incentives for innovation result in lower cost projects. The station walls shown here are simply attractive shotcrete coating of the indiginous rock, rather than the usual expensive practice of reinforced concrete. This example is located in Stockholm, Sweden.



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[by which] the owner would receive the completed construction at lower cost and the contractor would receive a just profit." "The new methods would also include provisions for equitable sharing of the risks. . . ." The approach was based on the consensus of construction experts that contracting for underground construction could be greatly improved to ". . . foster a cooperative atmosphere in which there is incentive for both the owner and the contractor to stimulate the use of advanced technologies and innovative construction techniques."

The study was based on extensive interview and exchange of questionnaire information with a full range of senior industry personnel in the United States and in seven European countries. Information was sought in three essential areas: 1) the content of construction bid packages, the process of bidding and letting contracts, and the terms of contracts, 2) the relationships between owners and contractors, especially regarding the effects on project management of changed geotechnical conditions, unanticipated effects on surrounding structures, opportunities for improvements for project design, and contract disputes; and 3) judgement regarding the effects of contracting procedures on the relationships between owners and contractors.

A major contrast was noted between the tendency of U.S. system owners to request firm fixed-price bids on rigidly defined designs and the European practice of encouraging contractor comment on system design and of negotiating contracts with cost reimbursement and incentive features.

In the opinion of the experts, the fixed-price approach, which tends to throw most of the risk on the contractor, provides little incentive to contractors for innovative approaches to design or construction or for candor regarding adequacy of design documentation. In effect, contractors are provided incentives for entering cost claims for design changes, unanticipated conditions, and delay beyond their control. Conversely, they have no basis for believing that past performance in avoiding litigation for cost claims will result in their selection. Also, awards to the lowest bidder "qualified" by securing a performance bond offers no opportunities to owners or their design agents to evaluate important contractor characteristics such as past safety performance, timeliness and final cost of projects in which they have participated, and ability to contribute to design or project economy improvements.

By contrast, European owners have substantial freedom to "prequalify" contractors relative to their record of performance and claims submissions, as well as to the qualification and experience of their personnel, financial strength, equipment availability, etc.

Associated advantages found in European practice are: provision for contractors to submit fully priced-out alternative designs; latitude for owners to negotiate with other than the lowest bidder if competence and probability of a lower total price warrants it; assumption of important risk categories (such as changed subsurface conditions) by owners; and, apparently as a result of contracts providing incentives for mutual reward, a much lower incidence of claim dispute and litigation.

Fixed Price
- Firm Fixed Price
- Fixed Price Escalation
- Fixed Price Incentive Firm

Cost Reimbursable
- Cost Plus Incentive Fee
- Cost Plus Award Fee
- Cost Plus Fixed Fee
- Cost Plus Percentage of Cost

Figure 5
Primary Contracting Format Options

Specifics regarding contracting practice in each of the seven European countries were extensively documented in categories such as *Processes for Advertising and Opening Bids, Criteria for Selection of Successful Bidders, Subsurface Data Available to Bidders, Contract Formation and Administration, Penalties and Bonuses,* and *Distribution of Risk.*

Additionally, seven primary contract options (Figure 5) were analyzed with respect to *Owner's*

Goals, the *Contractor's Motivation*, *Selecting Contract Type*, and *Speed of Completion*.

The experts who conducted the study presented their findings in workshops attended by specialists in underground construction. From this interplay, seventeen specific recommendations to improve U.S. contracting practice were developed. Some of the basic ideas which run through these recommendations are: 1) provide all available factual information and expert opinion in the bid package; 2) encourage contractors to provide technical opinions and alternative designs during the bid process; 3) assume those risks which bidders will tend to cover through substantial contingency bids or which could be the source of expensive dispute; and 4) provide financial rewards for economic, high quality performance and, conversely, penalties for failure.

Risk Allocation

UMTA funded successful development of a methodology (2) to provide a quantitative basis for making risk decisions in transportation construction. The procedure provides two fundamental outputs: 1) the cost saving available from assumption of risk by the parties to the project, and 2) the dollar value of obtaining information to reduce uncertainty (e.g., regarding subsurface geological conditions).

Put simply, the technique treats experts' judgements regarding uncertain situations as though they were probabilistic data. A decision analysis methodology treats this information analytically so that the cost of project risks can be used to negotiate their assignment among the parties.

In the "model building" phase (Figure 6) analysts ask the project participants to describe the risks they perceive in the project, the relationships among them, their consequences, and the process by which they make decisions regarding them. The analyst sketches out this representation of the participant's thinking and verifies that it is an accurate summary of the way in which the various factors interact.

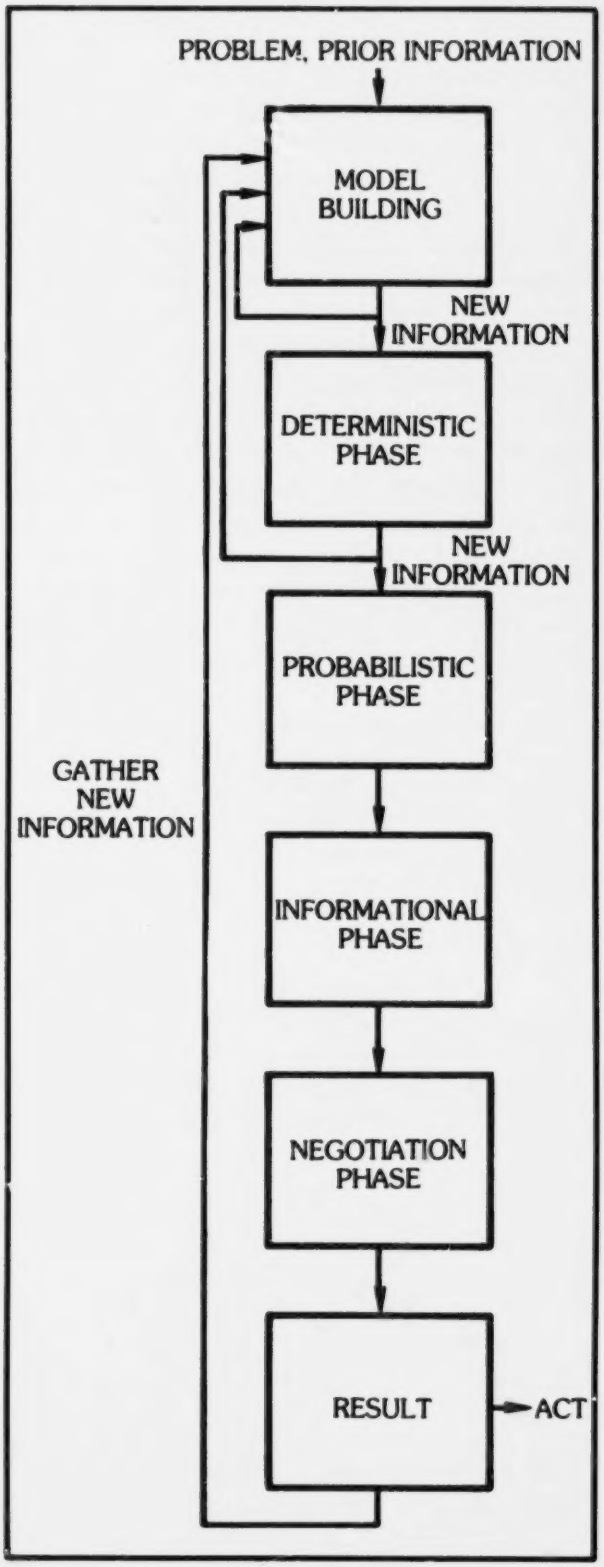

Figure 6
Decision Analysis Cycle

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An example of such a diagram is given in Figure 7. Important features of these diagrams are "state variables" (represented in Figure 7 as circles). Many of these can, to a degree, be controlled, so assumption of their risk can provide incentive to improve performance. For instance, the variable "contractor's safety program costs" is under the contractor's influence. If he bears these costs, he will seek ways to handle the program efficiently, as well as assure that accident rates are kept low.

In the "deterministic" and "probabilistic" phases, the analyst asks the participants to estimate the range of values possible for the variables and the probabilities associated with them. Using the information gathered to this point, the model is used to analyze the sensitivity of total program cost to each variable so the most important may be identified.

The "information" phase has to do with using the model to determine the reduction in total project cost of obtaining additional information.

In the "negotiation" phase, the models which have been developed independently for the various participants are brought together so risk allocation may be negotiated. The objective is to identify the optimum allocation of risk among the parties so as to produce the lowest expected project cost, to provide the greatest incentive to control those variables to which project economy is most sensitive, and to provide an economic basis for deciding where to seek more information.

The model was reviewed for realism and practicability by an extensive group of technical advisors in fields including bonding, contracting, design, engineering, management, construction law, geotechnical engineering, and transit authority management. Additionally, it was used to design insurance coverage for a realistic hypothetical project, the cost of which was compared to a similar actual project.

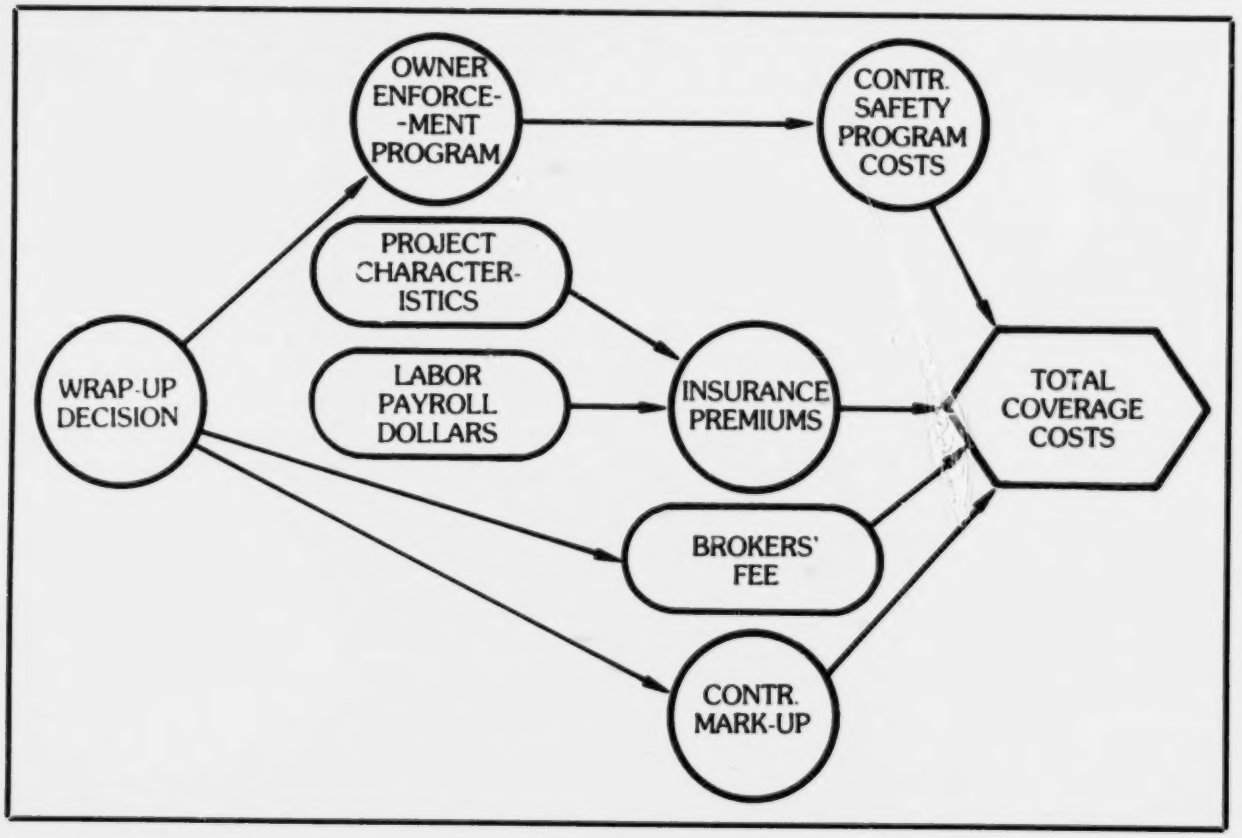

Figure 7
Contractor's Workers' Compensation Submodel

Although risk decisions can grow quite complex, as shown in Figure 8, work with actual project participants showed that the interviews were efficient—typically using a few tens of hours of project personnel time—and that the technique is practical and yields clear and useful decision results.

The study concluded that it is important that the technique include the project designer, thereby involving all major project participants. Additionally, it would permit utilization of the inherent capacity of the technique to produce the "value of information" data so important to defining appropriate preaward investigative efforts and appropriate contracting techniques in areas of uncertain geology.

To accomplish this, UMTA has funded extension of the research to " . . . develop a model which relates technical decisions . . . and . . . risks that design engineers take into consideration . . .", "to examine the impact of . . . design decisions . . . on the final cost . . .", and " . . . to determine the cost impact of varying contractural arrangements, and other decisions (e.g., amount of site investigation, insurance arrangements) related to [uncertain site conditions]." This project will include application to an actual project. The savings enjoyed and the concerns of an extensive technical advisory committee regarding the validity and application of the extended technique will be documented.

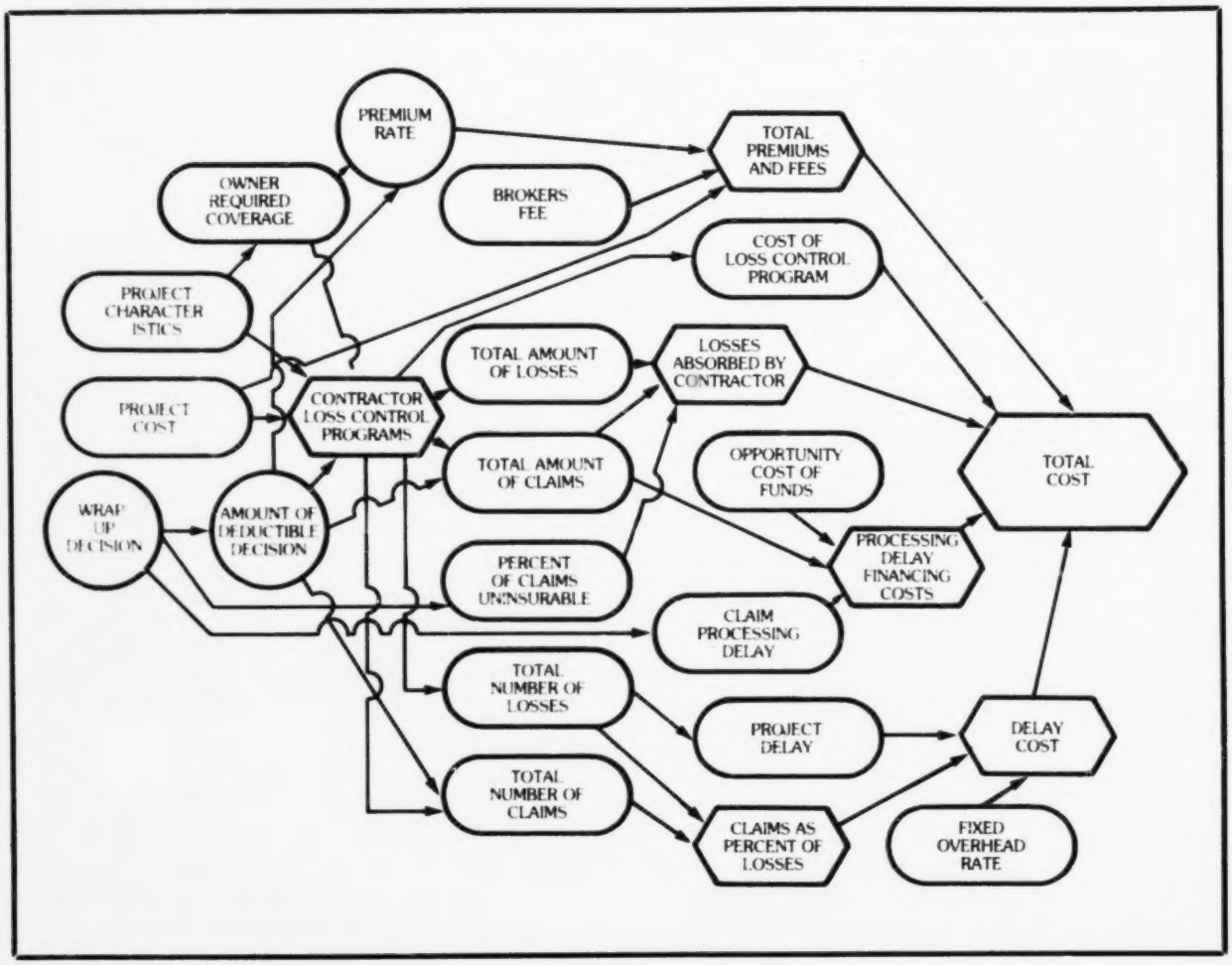

Figure 8
Contractor's Builders' Risk Submodel

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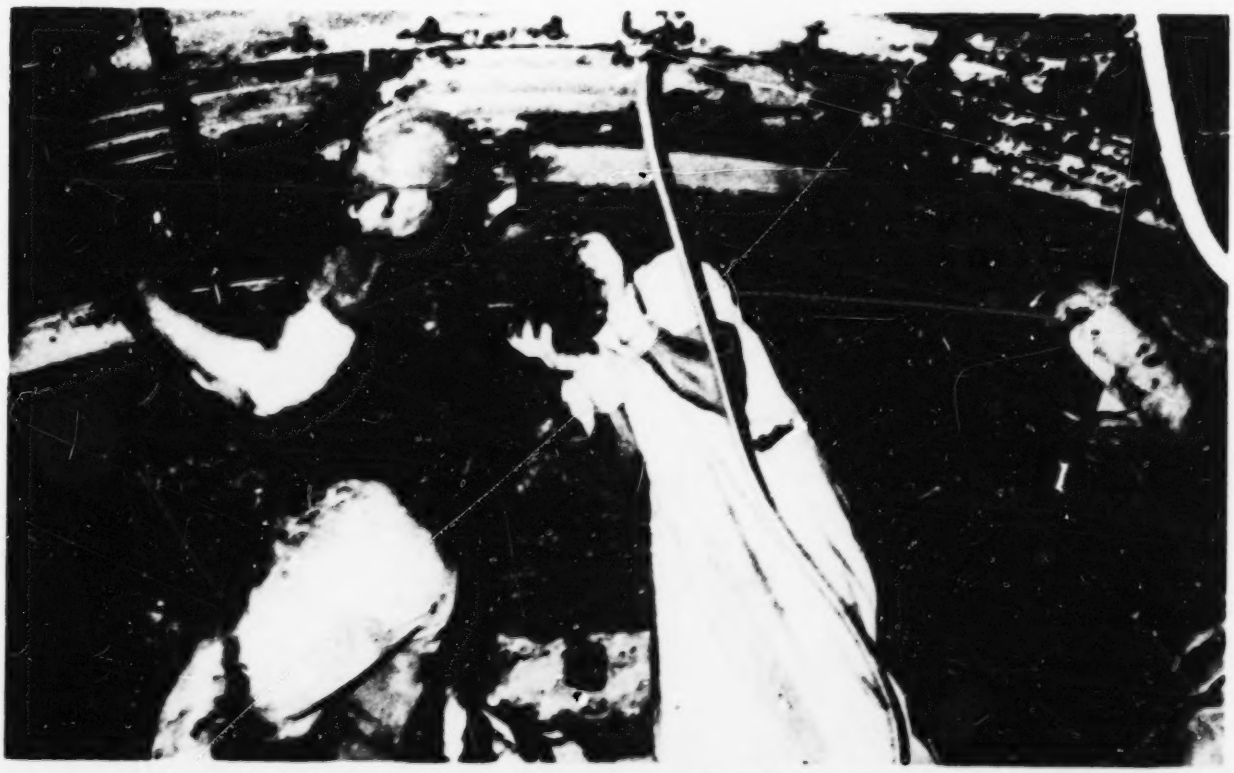
Urban rail construction is an inherently risky business. Management of risks, including vigorously implementated safety programs and equitable allocation of the costs of risks, provide powerful incentives for their control.

Insurance

In a 1979 study of insurance alternatives for the Niagara Frontier Transportation Authority's light rail rapid transit project (1), UMTA had opportunity for practical application of the risk assignment methodology. The methodology was used to identify participants' perceptions regarding the elements of risk in the project and their cost and probability. The technique also was used to reveal the "risk tolerance" of the participants and from this the most economic insurance package compatible with their willingness to self-insure themselves.

The analysis revealed that a comprehensive, or "wrap-up" insurance program would cost about 20% less in premiums and claims than insurance purchased directly by the contractors. Savings accrue from the overall efficiencies of the wrap-up program and the incentives for cost reduction in an effective safety program. For instance, savings of 15% in general liability insurance were



For those who work in the field, urban rail construction is difficult and dirty and can be dangerous. Safety is not only essential to morale and productivity, but study of insurance programs shows that the reduction in workmen's compensation costs brought about by practical and strict safety programs and by realistic evaluation and classification of workers' skills is the largest single insurance claims saving.

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possible because of the cheaper premiums of the volume insurance purchase, as were 10% savings in builders' risk. Similarly, the program featured high deductible levels for premium savings. The results of this self-insurance by the owner show a 10% savings in total costs for general liability and 15% savings in builders' risk.

The Niagara Transportation Authority adopted the recommended insurance package, and is anticipating savings in excess of the study predictions. Additionally, the neighboring Westway project is contemplating use of these analysts' techniques.

Since insurance is a major cost to urban rail transit construction, UMTA sponsored research which analyzed insurance options, provided recommendations for insurance formats, and provided extensive specific information regarding insurance specialists, available coverages, and insurance administration (5).

The study produced three insurance imperatives:

First, design and marketing of insurance must be considered part of management. It is essential that transit system owners thoroughly identify and estimate project risks at the beginning of a project and follow through with vigorous loss prevention programs, particularly in safety. *Second*, coordinated insurance, or "wrap-up" programs (in which the owner purchases the insurance for all the participants in the party, and administers the program) are the best format for construction projects costing more than $60 million; they are generally easiest to administer and afford great opportunities for savings through volume purchasing and avoidance of broker's fees. *Third*, insurance management should be handled by a professional insurance administrator allied with a national brokerage firm (or a consortium of such firms). Administration of large programs requires substantial professional expertise, and an administrator with national back- up can "market" the insurance for the best price.

Research was presented regarding the actual insurance program structure coverage and cost for four of the nation's major urban rail projects (San Francisco's BART, Washington's WMATA, Atlanta's MARTA, and Baltimore's MTA), including analysis of the capacity and history of various insurance administration firms, insurance companies, and consortia.

The dominant importance of workmen's compensation insurance cost was emphasized, including the extreme importance of appropriate worker classification and safety programs in limiting these costs. Ten specific guidelines for project safety programs were presented (Figure 9).

1. The owner should establish a system-wide safety program.
2. Contractor selection should be based on safety record.
3. Insurance programs should provide incentive to maintain favorable safety records.
4. Construction contracts should be scheduled so the pool of skilled workers will not be exhausted.
5. Mobilization payments to contractors should enable the procurement of tools, plant, and equipment needed to ensure safe construction.
6. A geotechnical program should be conducted with emphasis on safety.
7. Design criteria relating to safety should be established.
8. Contracts should identify natural hazards and specify requirements for conduct of work in their presence.
9. Each contractor should establish a safety program for each job.
10. Before being assigned underground, all workers should receive indoctrination in the nature of underground work, the details of the job, and their particular assignment.

Figure 9
Recommended Guidelines for Safety Programs

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The study made eleven specific recommendations:

1. *Early risk analysis*, planning and management are extremely important; owner leverage is greatest before contracts are let.
2. *Coordinated insurance programs* (CIP) or "wrap-up", should be used on projects larger than $60 million.
3. *Expert advisors* should be used in early planning.
4. *Periodic meetings* of those concerned with insurance (insurance, financial, construction, operations, legal, etc.) should be held.
5. The *insurance program* should be reviewed semi-annually.
6. The *insurance market* should be analyzed semi-annually.
7. The *stability of the project's insurance companies* should be reviewed semi-annually.
8. *State jurisdiction and appropriate job classification* are extremely important to workmen's compensation costs.
9. *Serious dedication to safety* programs is essential.
10. Base the program on the *technical experience of the industry*.
11. CIP can be improved by giving *monetary incentive* for good safety performance, by *paying workmen's compensation claims at the time of entitlement* rather than on an anticipated basis, and by seeking improvements through *competition among the insurance administrators* at the time of contracting.

Analysis of successful insurance programs shows that their design and operation require expert attention. Development of the insurance program and physical design of the project must proceed together. Also, insurance must be kept in good order through periodic review by those professionals whose work impacts risk costs and insurance administration.

Summary

There are lucrative opportunities for cost reduction through improved management and contracting in urban rail transit construction projects. UMTA has sponsored research in management structure and planning and in the contractual and insurance relationships with contractors. These studies have been conducted through consultation with a wide community of experts and, in general, are based on successful practice in this country.

Vigorous application of these techniques, UMTA believes, can result in substantially more cost effective urban rail transit projects.

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Most reports on UMTA research and development described in this volume are available to the public through the National Technical Information Service (NTIS). NTIS is the principal repository and disseminating agency for all reports issued in conjunction with federal research and development activities. To order reports from NTIS use the order numbers ("PB" numbers) listed after each report citation in the bibliography. The lack of an order number following the citation means that the report had not yet been entered into the NTIS system when this publication went to press.

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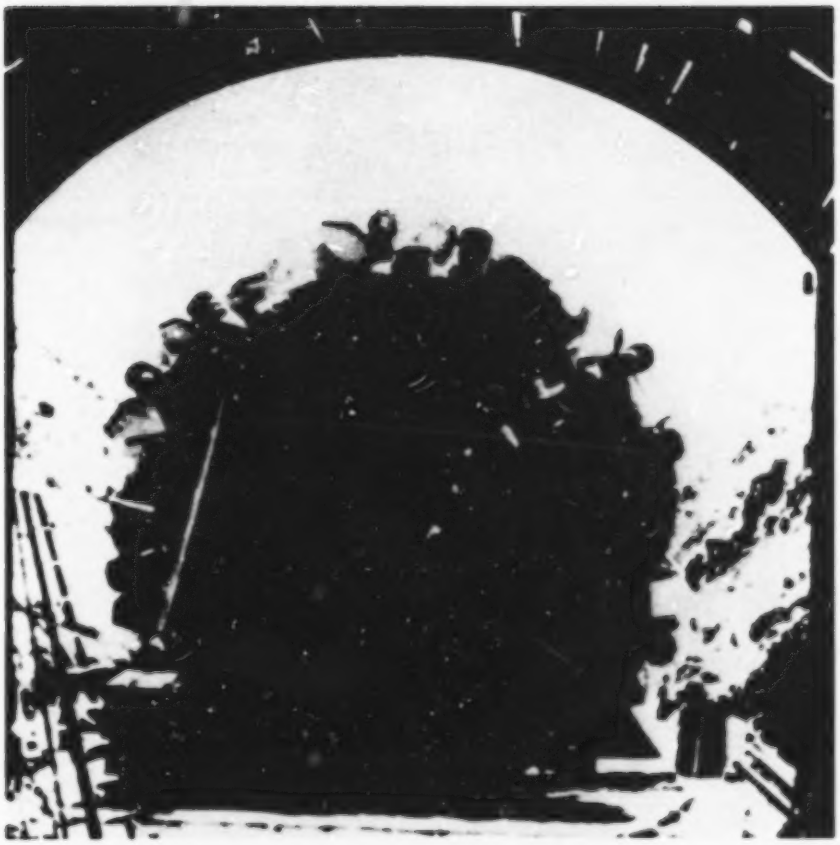

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